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AIM-IT: RAPID POINTING TO METEORS IN AIRBORNE OBSERVATIONS

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ABSTRACT

The first systematic survey of elemental composition and grain morphology of meteoroid streams will become feasible if imagers and spectrographs can be deployed from SOFIA. The usual approach is that of slit-less staring observations with a large field of view. This can only achieve low-resolution spectroscopy and low-spatial resolution imaging. Now, we have developed a new tool for increasing the field of view, called "AIM-IT". This device automatically acquires the meteor in a wide field of view and, by means of two mirrors, steers its light into the field of view of a narrow-field imager or slit spectrograph. The device was successfully tested during the 2002 Leonid MAC mission and from the ground during the 2003 Leonids. This tool can greatly expand the scientific opportunities for meteor observations from a future SOFIA Upper Deck Research Facility.

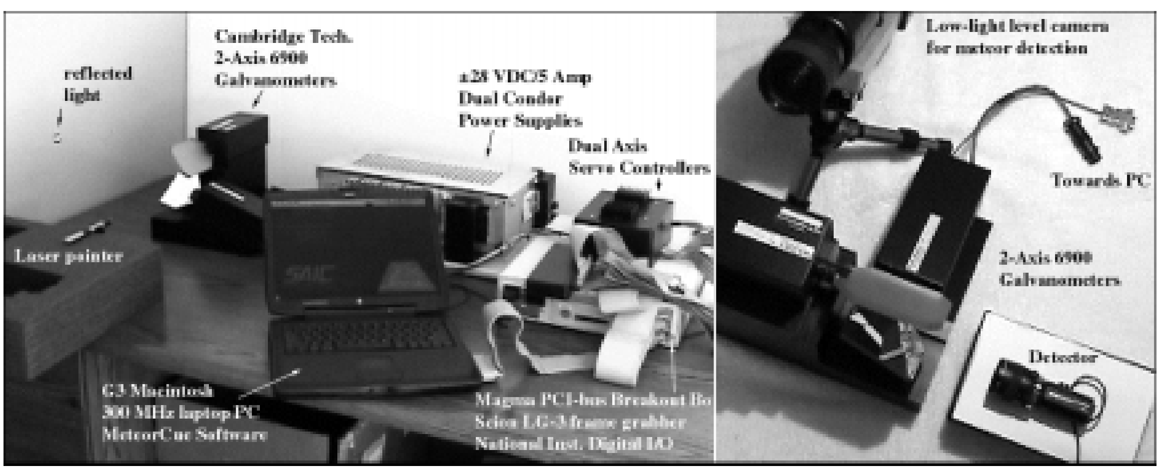

Fig. 1. AIM-IT instrument during testing and calibration of mirror control commands.

THE INSTRUMENT

Purpose of the AIM-IT instrument (Astrobiology Instrumentation for Meteor Imaging and Tracking) is to be able to gather light from fast meteors into the slit of an existing spectrograph during airborne observations of meteor showers, in search of clues about the fate of organic matter during meteor ablation. Meteors may have contributed unique prebiotic molecules to the origin of life (Chyba *et al.*, 1990, Jenniskens *et al.*, 2000, Des Marais *et al.*, 2003). This effort focuses fully on the technological difficulties of automatic meteor detection and rapid acquisition and tracking of meteors.

The instrument consists of a pair of *Cambridge Technologies* 2-axis 6900 galvanometers and dual axis servo controllers, powered by a 28 VDC/5 Amp dual condor power supply, that are controlled by MeteorCue software on a G3 MacIntosh laptop PC (Fig. 1). The light of a meteor in a low-light level wide field (40º x 40º) acquisition camera is detected, the position of the meteor measured, and translated into steering commands for the 2-inch clear-aperture mirror system. The light is reflected in orthogonal direction to a detector, which could be a narrow field imaging system, or the slit of a spectrograph.

Fig. 2. Left: NASA's "DC-8 airborne laboratory" and USAF's "FISTA" aircraft with participating researchers during the 2002 Leonid MAC mission. Right: George Varros with AIM-IT prototype.

FIELD TESTS

We started the project by building and testing a prototype based on automatic meteor detection from video, coupled to rapidly aiming a small camera. During the 2002 Leonid MAC mission (Jenniskens, 2002), this prototype was deployed from aircraft in an experiment led by George Varros (Fig. 2), who demonstrated that meteors can be detected in these difficult circumstances and a camera can be pointed rapidly enough. Meteor rates are 4-5 times higher than from the ground due to low extinction. We imaged numerous meteors, amongst which a bright fireball, but the pointing and tracking was not precise enough to steer the light into a narrow slit.

We then proceeded to construct the proposed system based on steering a set of mirrors. This AIMIT instrument is now assembled and was deployed and tested in ground-based observations at the University of Alaska, Fairbanks, during the 2003 Leonid meteor shower and, more recently, onboard the NKC-135 "FISTA" aircraft during the Genesis SRC Entry Observing Campaign in September 2004.

After the AIM-IT mirror assembly was built, we tested the AIM-IT instrument during the 2003 Leonid MAC mission at the University of Alaska, Fairbanks. The detector was a high frame-rate sensor that measured the position of the meteor in a narrow (5º) field of view at 1000 frames/s (Stenbaek-Nielsen & Jenniskens, 2003). This allowed us to test the accuracy of the steering commands and examine the motion of the rapidly moving meteor during the steering commands.

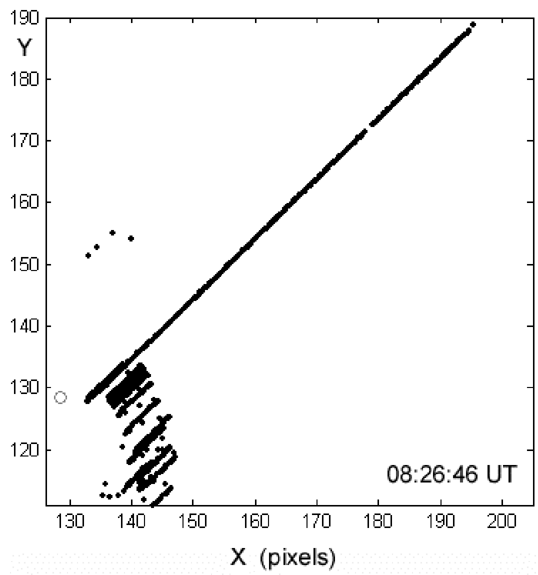

Fig. 3. Meteor of 2003 November 13, 08:26:46 UT, position on sensor as acquired with the high frame rate imager. Each dot is one image. Scale: 256 pixels = 5º.

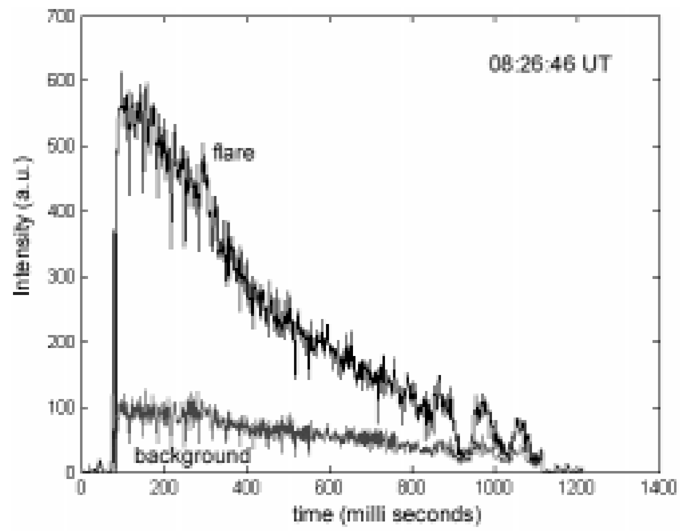

Fig. 4. Light curve for this same meteor. The periodic dips are due to light-loss when the meteor is positioned between two pixels.

Figure 03 shows an example of our results. The software was readjusting the mirrors every 1/30 s, after initial acquisition. This permitted the meteor to be positioned on the sensor within an area of ~ 20 x 20 pixels (0.4º x 0.4º). An error in the pointing algorithm is responsible for the gradual upward drift. This was subsequently corrected. After nine intervals (9/30 s), the meteor became too faint to be tracked and moved off towards the right. Fig. 4 shows the light curve of this meteor, as measured from the images, providing one of the most detailed lightcurves measured to date, without the usual uncertainties from angle-of-incidence dependent sensitivity of conventional photometers.

Finally, the now calibrated system was deployed during the 2004 Genesis SRC Entry observing campaign onboard the USAF "FISTA" aircraft. The instrument performed as expected, demonstrating its capability in potential future deployments on SOFIA.

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